

IN THE CLAIMS:

Please amend claims 3-10, 12, 14, and 16-25 as follows.

1. (Previously Presented) A method of estimating the location of a mobile device, comprising the steps of:

collecting location information;

selecting at least one of a plurality of different location methods to provide a location estimate said methods comprising using cell identity information; and

providing a location estimate based on the at least one selected location method.

2. (Original) A method as claimed in claim 1 wherein said at least one location method comprises at least one of the following methods:

a method using cell identity information;

a method using cell identity information and received signal strength;

a method using cell identity information and timing advance information; and

a method using cell identity information, received signal strength information and timing advance information.

3. (Currently Amended) A method as claimed in claim 1 ~~or 2~~, comprising the step of determining a virtual base station estimate.

4. (Currently Amended) A method as claimed in claim ~~3~~ 2, further comprising the step of determining a virtual base station estimate, when appended to claim 2, wherein said virtual base station estimate is determined using at least one of the methods of claim 2.

5. (Currently Amended) A method as claimed in claim 3 ~~or~~ 4, wherein said virtual base station location estimate coupled with at least one virtual measurement and at least one real measurement and said at least one virtual measurement is processed using a location method.

6. (Currently Amended) A method as claimed in claim 5 2, wherein said virtual base station location estimate coupled with at least one virtual measurement and at least one real measurement and said at least one virtual measurement is processed using a location method, and wherein the at least one real and the at least one virtual measurements are processed using a location method as defined in claim 2.

7. (Currently Amended) A method as claimed in claim 5 ~~or~~ 6, wherein a value for the virtual measurement is one of measured levels, a combination of measured levels, and an average of measured levels.

8. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said at least one location method is selected in dependence on the location information available.

9. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a plurality of location estimates are determined and at least one estimate is used to provide said location estimate.

10. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said location information is collected by said mobile device.

11. (Original) A method as claimed in claim 10, wherein said mobile device is arranged to measure a level of at least one type of information.

12. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said location information comprises at least one of timing advance information and received signal level.

13. (Original) A method as claimed in claim 12, wherein said received signal level is an absolute received signal level or relative received signal level.

14. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said mobile device is in a cellular communications device.

15. (Original) A method as claimed in claim 14, wherein said information is collected for a serving cell of the mobile device.

16. (Currently Amended) A method as claimed in claim 14 ~~or 15~~4, wherein said information is collected for at least one neighbouring cell.

17. (Currently Amended) A method as claimed in ~~any of claims 14 to 16~~ claim 14, comprising the step of selecting the or each cell in respect of which location information is collected.

18. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a location estimate is provided using the following algorithm

Calculate the total attenuation experienced by a signal transmitted by the i-th BTS while propagating toward a mobile station where i-th level observation is L^i) by subtracting from the i-th measured received power, P_r^i , the maximum power radiated by the i-th BTS, $P_{t,max}^i$:

$$L^i = P_r^i - P_{t,max}^i \quad ; \quad i = 1, \dots, N \quad (11)$$

Stack the level observations from N BTS's in vector \mathbf{L} :

$$\mathbf{L} = [L^1, \dots, L^N]^T \quad (12)$$

Solve the minimization problem:

$$\begin{bmatrix} \hat{\sigma}_u^2 \\ \hat{x} \\ \hat{y} \end{bmatrix} = \arg \min_{\begin{bmatrix} \sigma_u^2 \\ x \\ y \end{bmatrix}} F(x, y; \sigma_u^2) \quad (13)$$

where the *cost function* $F(x, y; \sigma_u^2)$ is defined as follows:

$$F(x, y; \sigma_u^2) = \ln \sigma_u^2 + \ln |\mathbf{r}_L(x, y)| + \frac{1}{\sigma_u^2} [\mathbf{L} - \mathbf{m}_L(x, y)]^T \mathbf{r}_L^{-1}(x, y) [\mathbf{L} - \mathbf{m}_L(x, y)] \quad (14)$$

and

$$\mathbf{m}_L(x, y) = [\mu_L^1(x, y), \dots, \mu_L^N(x, y)]^T \quad (15)$$

$$\mu_L^i(x, y) = -\text{PL}^i(d^i(x, y)) - AP_{tr}^i(\psi^i(x, y)) \quad (16)$$

$$[\mathbf{r}_L(x, y)]_{ij} = \begin{cases} 1 & i = j \\ \rho_u^{i,j}(x, y) & i \neq j \end{cases} \quad i, j = 1, \dots, N \quad (17)$$

19. (Currently Amended) A method as claimed in ~~any preceding claim~~ 1, wherein a location estimate is provided using the following algorithm

Calculate the total attenuation experienced by a signal transmitted by the i-th BTS while propagating toward a mobile station where the i-th level observation is L^i by subtracting from the i-th measured received power, P_r^i , the maximum power radiated by the i-th BTS, $P_{t,max}^i$:

$$L^i = P_r^i - P_{t,max}^i \quad ; \quad i = 1, \dots, N \quad (18)$$

Stack level observations from N BTS's in vector \mathbf{L} :

$$\mathbf{L} = [L^1, \dots, L^N]^T \quad (19)$$

Solve the minimization problem:

$$\begin{bmatrix} \hat{x} \\ \hat{y} \end{bmatrix} = \arg \min_{\begin{bmatrix} x \\ y \end{bmatrix} \in \mathcal{D}_{xy}} F(x, y) \quad (20)$$

where the *cost function* $F(x, y)$ is defined as follows:

$$F(x, y) = \sum_{i=1}^N \left(L^i + PL^i(x, y) + AP_{tr}^i(x, y) \right)^2 \quad (21)$$

and \mathcal{D}_{xy} is the domain of existence of x and y .

Calculate $\hat{\sigma}_u^2$ as

$$\hat{\sigma}_u^2 = F(\hat{x}, \hat{y}) \quad (22)$$

20. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a location estimate is provided using the following algorithm:

Calculate the total attenuation experienced by a signal transmitted by the i -th BTS while propagating toward a mobile station where the i -th *level observation* is L^i) by subtracting from the i -th *measured* received power, P_t , the maximum power radiated by the i -th BTS, $P_{t, \max}^i$:

$$L^i = P_r^i - P_{t, \max}^i \quad ; \quad i = 1, \dots, N \quad (23)$$

Calculate the j -th *level difference observation* by subtracting the j -th level observation from the level observation L^1 taken as reference:

$$D^j = L^1 - L^j \quad ; \quad j = 2, \dots, N \quad (24)$$

Stack the $N - 1$ difference of level observations in a vector \mathbf{D} :

$$\mathbf{D} = [D^2, \dots, D^N]^T \quad (25)$$

Solve the minimization problem

$$\begin{bmatrix} \hat{x} \\ \hat{y} \end{bmatrix} = \arg \min_{\begin{bmatrix} x \\ y \end{bmatrix} \in \mathcal{D}_{xy}} F(x, y) \quad (26)$$

where

$$F(x, y) = \sum_{j=2}^N (D^j - \mu_D^j(x, y))^2 - \frac{1}{N} \left(\sum_{j=2}^N D^j - \mu_D^j(x, y) \right)^2 \quad (27)$$

and

$$\mu_D^j(x, y) = - \left[\text{PL}^1(d^1(x, y)) - \text{PL}^j(d^j(x, y)) \right] - \left[\text{AP}_{tr}^1(\psi^1(x, y)) - \text{AP}_{tr}^j(\psi^j(x, y)) \right] \quad (28)$$

\mathcal{D}_{xy} is the domain of existence of x and y .

21. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a location estimate is provided using an algorithm solving the following equation in x and y :

$$\begin{cases} \sum_{i=1}^N F^i(x, y) (x - x^i) = 0 \\ \sum_{i=1}^N F^i(x, y) (y - y^i) = 0 \end{cases} \quad ; \quad (x, y) \in \mathcal{D}$$

where

$$F^i(x,y) = \frac{2B^i/C^i(d_0)}{(2\pi)^{3/2} \sigma_u^i \ln 10} \frac{\exp \left\{ -\frac{1}{2\sigma_u^{i2}} (B^i \log_{10} d^i(x,y) - z^i + A^i)^2 \right\}}{[d^i(x,y)]^4} \cdot \left[\frac{B^i (B^i \log_{10} d^i(x,y) - z^i + A^i)}{2\sigma_u^{i2} \ln 10} - 1 \right]$$

22. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a location estimate is provided using an algorithm solving the following equation in x and y :

$$\begin{cases} \sum_{i=1}^N \left[-\frac{\mathcal{I}_i}{|\mathbf{R}|} (x - x^i) - \frac{(\tilde{\mathcal{I}}_i - 1)}{|\mathbf{R}|} \{ (x^i)^2 x - x^i y^i (y - y^i) \} \right] = 0 \\ \sum_{i=1}^N \left[-\frac{\mathcal{I}_i}{|\mathbf{R}|} (y - y^i) - \frac{(\tilde{\mathcal{I}}_i - 1)}{|\mathbf{R}|} \{ (y^i)^2 y - x^i y^i (x - x^i) \} \right] = 0 \end{cases} ; (x,y) \in \mathcal{D}$$

23. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein a location estimate is provided using an algorithm based on the following equation:

$$\hat{x} = \frac{\sum_{i=1}^N \frac{x^i}{\mathcal{I}_{i0}}}{\sum_{i=1}^N \frac{1}{\mathcal{I}_{i0}}} ; \quad \hat{y} = \frac{\sum_{i=1}^N \frac{y^i}{\mathcal{I}_{i0}}}{\sum_{i=1}^N \frac{1}{\mathcal{I}_{i0}}} ; \quad (\hat{x}, \hat{y}) \in \mathcal{D}$$

24. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said location estimate is provided by one of a iterative and a closed form method.

25. (Currently Amended) A method as claimed in ~~any preceding~~ claim 1, wherein said location estimate is provided by one of a linear and non linear method.

26. (Previously Presented) A system for estimating the location of a mobile device, comprising:

means for collecting location information;

means for selecting at least one of a plurality of different location methods to provide a location estimate said methods using cell identity information; and

means for providing a location estimate based on the at least one selected location method.